CLAIMS

1. A separator material that is a sulfonated nonwoven that comprises a polyolefin ultra-fine short fiber having a fineness of less than 0.5 dtex and other polyolefin short fibers, wherein the other polyolefin short fibers include a polyolefin thermal bonding short fiber, and at least a portion of the polyolefin thermal bonding short fiber is flattened to bond the component fibers together, and

the nonwoven has a specific surface area in a range of 0.6 m^2/g to 1.5 m^2/g and satisfies the following ranges:

(1) a ratio $(S/C)_E$ of the number of sulfur atoms (S) to the number of carbon atoms (C) in the nonwoven, as measured by Electron Spectroscopy for Chemical Analysis (ESCA), is in a range of 5×10^{-3} to 60×10^{-3};

(2) a ratio $(S/C)_B$ of the number of sulfur atoms (S) to the number of carbon atoms (C) in the nonwoven, as measured by a flask combustion technique, is in a range of 2.5×10^{-3} to 7×10^{-3}; and

(3) a ratio $(S/C)_E/(S/C)_B$ (depth of sulfonation) of $(S/C)_E$ to $(S/C)_B$ is in a range of 1.5 to 12.

2. The separator material according to claim 1, wherein a depth of sulfonation is in a range of 1.5 to 9.

3. The separator material according to claim 1, wherein a tensile strength in a longitudinal direction of the nonwoven is 100 N/5cm or more as measured in accordance with JIS-L-1096.

4. The separator material according to claim 1, wherein, in a thickness direction of the nonwoven, a proportion of the flattened fiber constituting a surface layer portion of the nonwoven is larger than that of an inner portion of the nonwoven.

5. The separator material according to claim 1, wherein, when an amount of the nonwoven is assumed to be 100 parts by mass, an amount of the polyolefin ultra-fine short fiber is in a range of 20 parts by mass to 80 parts by mass, and an amount of the other polyolefin short fibers is in a range of 80 parts by mass to 20 parts by mass, and among the other polyolefin short fibers, a polyolefin thermal bonding short fiber is included in a range of 50 mass% to 90 mass%.

6. The separator material according to claim 1, wherein the other polyolefin short fibers include a polyolefin high-strength short fiber having a fiber strength of 5 cN/dtex or more in addition to the polyolefin thermal bonding short fiber.

7. The separator material according to claim 1, wherein the polyolefin ultra-fine short fiber has a fineness in a range of 0.03 dtex to 0.3 dtex.

8. The separator material according to claim 1, wherein the polyolefin ultra-fine short fiber is a short fiber obtained by splitting at least a portion of a splittable composite short fiber.

9. The separator material according to claim 8, wherein the splittable composite short fiber comprises a polymethylpentene resin as one component.

10. The separator material according to claim 1, wherein the other polyolefin short fiber has a fineness in a range of 0.5 dtex to 5 dtex.

11. The separator material according to claim 1, wherein the nonwoven is a wetlaid nonwoven that is obtained by a hydroentangling process.

12. The separator material according to claim 1, wherein the sulfonation is introduction of functional groups containing sulfur atoms using SO_3 gas.

13. A method of producing a separator material comprising:

subjecting fibers comprising a polyolefin ultra-fine short fiber having a fineness of less than 0.5 dtex and other polyolefin short fibers to a wetlaying process, the other polyolefin short fibers including a polyolefin thermal bonding short fiber;

subjecting the fibers to a heat treatment at a temperature at which the polyolefin thermal bonding short fiber melts, and flattening at least a portion of the polyolefin thermal bonding short fiber, to thermally bond the component fibers together;

thereafter, subjecting the component fibers to a hydroentangling process to entangle together;

thereafter, imparting functional groups containing sulfur atoms to the fibers by a sulfonation treatment; and

thereafter, subjecting the fibers to a heat press process, thereby obtaining a nonwoven having a specific surface area in a range of 0.6 m^2/g to 1.5 m^2/g.

14. The method of producing a separator material according to claim 13, wherein, in a step before the wetlaying process, a splittable composite fiber and another polyolefin short fiber comprising a polyolefin thermal bonding short fiber are prepared, and at least a portion of the splittable composite fiber is preliminarily split to obtain the polyolefin ultra-fine short fiber having a fineness of less than 0.5 dtex.

15. The method of producing a separator material according to claim 13, wherein, after performing the hydroentangling process, a heat treatment is performed at a temperature that is lower than a melting point of the

polyolefin thermal bonding short fiber, and thereafter, a sulfonation treatment is performed.

16. The method of producing a separator material according to claim 13, wherein the separator material is a wetlaid web in which the other polyolefin short fibers include a polyolefin high-strength short fiber having a fiber strength of 5 cN/dtex or more in addition to the polyolefin thermal bonding short fiber, and at least a portion of the polyolefin high-strength short fiber is flattened.

17. The method of producing a separator material according to claim 13, wherein the sulfonation treatment is an SO_3 gas treatment at a temperature in a range of 40°C to 90°C.

18. The method of producing a separator material according to claim 13, wherein the hydroentangling process is to apply a water jet with a water pressure in a range of 2 MPa to 10 MPa.

19. The method of producing a separator material according to claim 13, wherein the heat press process is a calender roller process in which a pair of calender rollers having a temperature that is higher than 40°C and is lower by 30°C or more than a temperature at which the component fibers melt, are used to press the nonwoven with a line pressure in a range of 150 N/cm to 1500 N/cm.

20. The method of producing a separator material according to claim 13, wherein a ratio of a specific surface area of the nonwoven to an apparent specific surface area of the nonwoven calculated from a specific surface area of the fiber constituting the nonwoven (specific surface area increase rate), is regulated to be in a range of 115% to 200%.

21. An alkali secondary battery separator comprising a separator material that is a sulfonated nonwoven that comprises a polyolefin ultra-fine short fiber having a fineness of less than 0.5 dtex and other polyolefin short fibers, wherein the other polyolefin short fibers include a polyolefin thermal bonding short fiber, and at least a portion of the polyolefin thermal bonding short fiber is flattened to bond the component fibers together,

the nonwoven has a specific surface area in a range of 0.6 m^2/g to 1.5 m^2/g and satisfies the following ranges:

(1) a ratio $(S/C)_E$ of the number of sulfur atoms (S) to the number of carbon atoms (C) in the nonwoven, as measured by Electron Spectroscopy for Chemical Analysis (ESCA), is in a range of 5×10^{-3} to 60×10^{-3};

(2) a ratio $(S/C)_B$ of the number of sulfur atoms (S) to the number of carbon atoms (C) in the nonwoven, as measured by a flask combustion technique, is in a range of 2.5×10^{-3} to 7×10^{-3}; and

(3) a ratio $(S/C)_E/(S/C)_B$ (depth of sulfonation) of $(S/C)_E$ to $(S/C)_B$ is in a range of 1.5 to 12.